DOCUMENT RESUME

ED 443 322 HE 033 077

AUTHOR	Ruzic, Roxanne
TITLE	New Solutions, New Barriers: Current Uses of the Web in Higher Education.
PUB DATE	2000-04-26
NOTE	38p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 24-28, 2000).
AVAILABLE FROM	A digital version of this paper is available at http://www.cast.org/presentations/rruzic/AERA2000.html.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150) -- Tests/Questionnaires (160)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	College Faculty; College Students; Computer Networks; *Computer Uses in Education; Disabilities; *Diversity (Student); *Educational Technology; Foreign Countries; Higher Education; Interviews; *Literature Reviews; Special Needs Students; Student Attitudes; Teacher Attitudes; Teaching Methods; *World Wide Web
IDENTIFIERS	Canada

ABSTRACT

This paper examines the use of network technologies in higher education and explores how adaptable network tools are for particular learning and teaching environments. The study included a review of the literature describing World Wide Web use to support learning in postsecondary courses in the United States and Canada. Additionally, interviews were conducted with 16 students in three classes at two institutions in which Web technology was used, as well as with four instructors. Data examined included student profiles, class topic, network tool, pedagogical tool, context, adaptable system components, educational purpose, and evaluation. The study found Web-based learning at all levels (undergraduate, graduate, professional) and in many different kinds of institutions, with the majority of courses concentrated in scientific and technical subject areas, which do not include many students with identified special needs. Instructors most often use the Web to enhance communication with students; to provide links to outside resources; and to post course information. Teachers struggle to meet students' differing needs because development of Web-based material is so time-consuming. Appended are a list of the literature reviewed, questions applied to the literature review, and interview protocols. (Contains 35 references.) (SM)

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New Solutions, New Barriers: Current Uses of the Web in Higher Education

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Annual Meeting of the American Educational Research Association
New Orleans, LA
April 26, 2000

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Introduction and Research Questions

Three trends currently converging in United States higher education have implications for how students will learn with emerging technology at the start of the next century. First, demographics of colleges and universities are changing as increased proportions of students from a range of cultures, races, and ages enroll (Culross, 1996; Halpern, 1994; Twigg, 1994; Twigg & Oblinger, 1996). Second, educational research and teaching communities are acknowledging that different learners have different needs (e.g., Boyd & Mitchell, 1992; Gardner, 1983; Miller, 1996). Third, the increasing popularity of the World Wide Web and Internet technology is making Web-based course supports the expectation in more and more segments of higher education (Gan, 1997; Green, 1998). In fact, according to the 1998 National Survey of Information Technology in Higher Education, almost a quarter of all college courses currently employ Web pages for "class materials and resources," up from 8% just two years before (Green, 1998).

The convergence of these trends provides an opportunity. Evidence so far indicates that student populations, network technology, and beliefs about learners' different needs all affect the structure of college classrooms. Preliminary research suggests that the network can be a powerful tool for customizing experiences to particular learners, as well as for involving students who traditionally feel excluded from classroom activity (Brummel, 1994; Massy, 1995). For instance, making course materials available in digital format can greatly help students with various disabilities. As an example, students with certain kinds of visual disabilities can better access and navigate through digital text-based material by changing such characteristics as font size and screen contrast, or by converting text to synthesized speech. These adaptations are not possible when materials are in traditional paper format.

But technological solutions designed to remove barriers for one student often lead to new barriers for others. The Web creates both possibilities and problems in these areas. Graphical displays and three-dimensional animations not possible in paper lessons can help visual learners better comprehend course content. But these non-text-based depictions -- even in digital format -- often remain inaccessible to students with vision impairments. And exercises which take advantage of the currency of information on the Web by engaging students with references to popular culture may create barriers for foreign students who are unfamiliar with the cultural topics described.

These barriers are not erected intentionally; they are cases of oversight. While many in post-secondary teaching, administration, and publishing are eager to introduce network learning to the classroom, only about 40% of post-secondary institutions currently have any kind of curriculum or instructional plan to guide instructors' use of the Internet in courses (Green, 1998), let alone a plan designed to include all learners. As the use of Web and Internet technology to support college courses increases exponentially, how can we take advantage of the possibilities digital technology provides for new pedagogical formats and customization without inadvertently excluding particular students?

While addressing the challenge of improving learning with technology for all students in the college and university system will not be an easy task, it is an important task. A first step is to understand what instructors and students are currently doing with the Web, and how they perceive the adaptability and inclusivity of the systems they are using. Toward this end, I

conducted a review of the literature and an interview study of network learning in selected post-secondary environments in 1998-99. The research was driven by the following two questions:

- What are the prevalent ways in which particular network technologies are currently used in higher education settings?
- How adaptable are the components of the network tools, embedded in particular teaching and learning environments, for students with different preference, strengths, and needs?

The Studies: An Overview

I attempted to answer my two research questions using two sets of data. First, in an attempt to answer these questions broadly, I conducted a review of the fairly limited body of literature that describes Web use to support learning in post-secondary courses in the United States and Canada that was available at the time of the study. Second, in an attempt to answer these questions more deeply, I interviewed students and faculty members who used Web technology in three courses during 1998. Two of these courses were given at a large, urban, post-secondary institution serving a diverse population in the greater Boston area, and one course was given in a more suburban setting which serves mostly older, working undergraduates in the Northeast. In both the literature review and the interviews, I asked the same questions. These questions related to eight areas of interest designed to give me a sense of the context of the class, the characteristics of the students described in each article or with whom I spoke, and both students' and instructors' perceptions of the flexibility of and reasons for particular uses of Web technology in each course. A list of the specific sub-questions I posed in each area of interest is contained in Appendices B and C. I will turn first to the review of the literature.

Review of the Literature: Method

In the literature review, I attempted to identify various uses of the Web within particular courses in post-secondary settings by looking at as broad a range of articles on the subject as possible. Through a search of pertinent academic databases (e.g., ERIC, PsycINFO, Academic Index) and the World Wide Web, I uncovered just twenty published case studies or descriptions of the use of a Web tool in a post-secondary course in the United States and Canada. These twenty articles are listed in Appendix A, and I have used all of them in my review.

With each article, I focused on eight categories concerning the context, use, and adaptability of the network tool described: student profiles, class topic, network tool, pedagogical use, context, adaptable system components, educational purpose, and evaluation. A list of the specific questions I applied to the literature is contained in Appendix B.

Review of the Literature: Findings

Most of the articles I reviewed were descriptions of a single class written by the instructor of that class. Only two of the twenty articles compared students using the Web to students not using the Web in a controlled study. Very few articles mentioned significant distinctions between students, and even fewer noted any adaptable components in the Web systems used in the course described. (These areas should be explored further if we are to understand and respond effectively to individual differences in the use of network technology.) The information available on each of my eight categories of interest in the twenty articles is summarized in the table below, and more specific commentary follows.

Table 1: Summary of information contained in articles about Web use in post-secondary settings in the United States and Canada. (n = 20)

	Yes, information reported	No information reported	Examples
(1) Student profiles	14 articles	6 articles	Year in school; area of study; location of institution
Differentiation?	8 articles	12 articles	Level of knowledge about subject matter and/or technology; gender; major; live on campus or not; facility with English
(2) Class topic	17 articles	3 articles	Computer science; engineering; statistics; instructional design; education; political theory; history of opera
(3) Network tool	20 articles	0 articles	Web site, including digital course materials and discussion facility; designed Web-based system (e.g., WebCT, Virtual-U); intranet
(4) Pedagogical use	16 articles	4 articles	Discussion; communication; presentation; collaboration; access to course materials; information gathering via links
(5) Context (location and timing)	14 articles	6 articles	Anywhere, anytime as desired; anywhere, anytime, but required to log in periodically; anywhere at a specified time; in class at a specified time; in computer lab at a specified time
(6) Adaptable system components	5 articles	15 articles	Display (black & white or color, choice of color); navigation (linear, hierarchical, via spaces, map, menus, control panel, hot keys); response (suggested paths, examples based on previous work, choice of method of submission of work)
(7) Educational purpose	8 articles	12 articles	Acquaint students with technology; provide for active learning, engagement; enable quick feedback; share work with others; customize learning; bring distant people together
(8) Evaluation	11 articles	9 articles	
Experimental Performance	2 articles		Compared grades of students using Web and not using Web in same class; compared grades based on grades predicted from previous courses for students using and not using Web in same class
Experimental Affect	5 articles		Surveys of student satisfaction with system/in course
Anecdotal Performance	1 article		Professor "struck by quality of responses on-line"
Anecdotal Affect	6 articles		Professor related impressions of student satisfaction

(1) Student profiles was intended to give me a sense of the characteristics of the students using the Web. The twenty articles included mention of students at all levels: 1st, 2nd, 3rd, and 4th year undergraduates; transfer students; master's students; doctoral students; and professional school students. Institutions across the U. S. and Canada were represented, and included elite schools, second-tier schools, and community colleges.

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As for differentiation, eight of the articles did mention differences in the abilities, backgrounds, or needs of the students in the class described. Among the differences noted were levels of knowledge about the course subject matter; levels of familiarity or comfort with computer technology; gender; ethnicity; major; and facility with English. It is important to note that two thirds of the articles made no mention of differences within the student population described in the article (and half of those articles did not mention student profiles in any way).

(2) Course topics ranged from computer science to political theory to the history of opera. Eleven of the seventeen articles that indicated the subject matter taught, however, described courses dealing with highly technical subjects, such as computer programming, engineering, statistics, and the design of technical systems. This is not surprising, as computers in education have historically infiltrated first the sciences (where instructors and students tend to be competent and comfortable with technology), and only later the humanities. Since, at present, most courses are being put on the Web through the initiative of the instructor, it makes sense that instructors who use computer technology frequently in their work are the instructors who also report using them in their teaching.

(3) The Network tools mentioned were almost exclusively Web sites developed by the instructors. Two authors described a system for Web-based conferencing, and one used WebCT, a program that helps instructors create Web sites (WebCT was, however, initially developed by the author of the article). All twenty of the articles mentioned the use of a network tool, as the articles would not have been included in this literature review if they had not discussed such use.

(4) To what end did the instructors use the Web tools? Pedagogical use included student tutorials for problem-solving; discussion, collaboration, and communication between students and between professors and students; presentation of materials to the instructor, the class, or the whole Internet community; links to on-line resources; and, occasionally, assessment. The most common reported use of the Web was for communication or sharing of work or ideas between professors and students or students and students (Burgstahler, 1997; Couples and Luke, 1998; Downing & Rath, 1997; Frick, Corry, & Bray, 1997; Goldberg, 1997; Gray, 1996; Hong, Toye, & Leifer, 1994; Powers & Mitchell, 1997; Rosen & Petty, 1997; Santi, 1997; Schutte, 1998; Sugrue & Kobus, 1997; Talley, 1997; Teles & Collings, 1997). The second most common reported use was for professors to post course materials and information, so that students could access it from anywhere at any time, saving class time or other resources (Burgstahler, 1997; Couples & Luke, 1998; Downing & Rath, 1997; Goldberg, 1997; Powers & Mitchell, 1997; Rosen & Petty, 1997).

Note that these two most common uses of the Web replace or augment a way of doing something the instructors did formerly in their classes; they do not yet constitute a new way of learning with technology. Internet-based communication replaces or augments face-to-face office hours and discussion sections, and course information and handouts available via a Web site replace or augment the distribution of course materials to students in paper handouts during class time. And while discussion of course content can be a core element of the instructional process, the distribution of course information is largely administrative, and therefore tangential to the learning process.

(5) The Context in which the students used the Web was, by virtue of the technology, anywhere there was an Internet connection, and any time. Some instructors set up times for students to meet in synchronous communication on-line, either from remote locations or together in a computer lab. While some instructors allowed the students to log on completely at their own discretion, others did not specify particular times and places, but required that students log in a minimum number of times a week.

(6) Adaptable system components were not mentioned by many authors. Of the five instructors who mentioned adaptability at all, the most sophisticated discussion by far is a description of ELM-ART, an interactive textbook and problem solving environment developed by the article authors (Brusilovsky, Schwartz, & Weber, 1997). This system, for teaching students the computer language LISP, allows students to test LISP expressions they write in the context of an interactive textbook on the subject. The system keeps track of which programming problems the student solves, and how. It then draws on this information to provide help (similar examples relevant to the student's level of expertise and problem solving style) when she is solving a new problem. In addition, hyperlinks to other materials are presented based on what the particular student has already done: the information "not ready to be learned" is red and italicized, that which is "ready and recommended" is green and bold, and that which is "ready but not recommended" is yellow and plain text (Brusilovsky, Schwartz, & Weber, 1997). Note that the authors of the system have provided multiple ways to obtain this information about skill level, both through color and through type style. The student can also work on problems in a number of ways: by reading examples presented by the computer in any order they choose; by going (through the aforementioned links) to textbook material on the problem type; or by beginning but not completing a problem and allowing the system to evaluate the answer through a series of increasingly detailed help messages.

Other articles which mentioned flexibility referred to the ability to choose a means of navigation (e.g., linear, hierarchical, spatial, menu-driven) or presentation of materials (e.g., black and white or color display) (Goldberg, 1996; Harasim, Calvert, & Groeneboer, 1997; Teles & Collings, 1997). Authors also cited the ability for students to choose to appear publicly or privately, openly or anonymously in on-line discussions, using their usernames or aliases in either e-mail or chat formats (Couples & Luke, 1998; Santi, 1997). Mention of how flexible Web-based systems could be used to support people with disabilities was noticeably absent in the articles I reviewed. The sole exception was an article describing a course for students of rehabilitative medicine who presumably deal with large numbers of students with disabilities (Burgstahler, 1997).

Yet the potential for flexibility in digital, Web-based formats is immense. It is possible to alter the look of materials, including changing the size, color, and contrast of text and on-screen elements like images to make them easier to view. Text can be translated into speech, with a variety of voices, pitches, and speeds. It is possible to navigate through materials in a variety of ways, including menus, buttons, maps, control panels, hot keys, or a single switch. Students can communicate with others through text, but also via graphics, recorded speech, and video. If an exercise is set up to include options, students can choose their own topics or activities from a set of choices or make up their own. They can complete these activities using a variety of formats, including text, graphics, and sound. Since the Web allows for individual timing and exploration, students can enter or complete activities using a variety of routes, including answering a question,

working from a partially finished solution, or working backwards from a completed example. Exercises, which are often completed on a student's own time, could be timed or untimed, in competition with other members of the class or not, and due dates could be minutes, hours, days, or weeks away. Materials can be re-formatted to allow for a choice of exam formats, such as multiple choice, fill-in-the-blank, or completely personal creation on the fly. Students can work with or share their work with no one, the instructor, a single classmate, a small group, the whole class, a distant expert, or all interested users of the World Wide Web. While these are just a subset of what is possible, the findings from the literature suggest that making such choices available -- especially different choices for different students -- is not a focus for instructors at this time.

(7) Only half the authors explicitly indicated the Educational purpose of the Web-based pieces of the class. Some that did cited the chance for active learning and quick feedback, the chance to enable students to experience multiple representations of course materials or learn in an individualized way, or to truly engage with subject matter by "doing" the course subject (Aberson, et al., 1997; Brusilovsky, Schwartz, & Weber, 1997; Sugrue & Kobus, 1997). Several cited the chance for students to become familiar with technology as an end in itself (Aberson, et al., 1997; Downing & Rath, 1997; Gray, 1996; Powers & Mitchell, 1997). Others mentioned logistical purposes, such as more easily bringing together people who are distant (Couples & Luke, 1998; Frick, Corry, & Bray, 1997). Once again, only one author cited more effectively including people with disabilities in learning activities as one of her educational purposes (this again was for the class in Adaptive Technologies specifically geared towards students of rehabilitative medicine and education) (Burgstahler, 1997).

(8) Finally, about half the articles made some mention of the Evaluation of the Web-based materials, either related to student performance or affect. (The other articles contain only descriptions of the system used in class, without evaluation of its effectiveness.) As previously noted, only two articles contained experimental data; both found that the students with access to the Web did the best and had the best attitudes toward the class and the subject matter as compared with students not using the Web (Goldberg, 1997; Schutte, 1998). One author indicated that students in the on-line section may have spent more time on the material; this factor may account for their better performance in the course. But the same students also reported higher satisfaction with the subject matter and course than students without access to the Web (Schutte, 1998).

In keeping with this finding, a number of authors reported that their students said they participated more or enjoyed participating more on-line than they would have in a traditional class (Burgstahler, 1997; Powers & Mitchell, 1997; Sugrue & Kobus, 1997; Talley, 1997). In fact, of all the evaluation reports offered, only two indicated any negative aspects of course Web use. One instructor reported that the system his students used was running on an unusually slow network that could take up to 30 minutes to download e-mail, and the students did not enjoy the wait (Rosen & Petty, 1997). Another instructor indicated that those students in his class who enjoyed thinking about the class itself as well as the subject matter enjoyed the class. In contrast, those who were in the class without any interest in improving the class itself did not enjoy the uncertainty and troubles associated with experimenting in a new technological medium (Peron, 1994).

Review of the Literature: Conclusions and Caveats

In summary, according to current reports of Web use at the post-secondary level as presented in the literature, students are experiencing Web-based learning at all levels (undergraduate, graduate, professional school), and in many different types of institutions (elite, second-tier, community college). If the literature is any indication, the majority of courses that use the Web are still concentrated in scientific and technical subject matters, such as computer science, engineering, and systems design.

Instructors are using the Web in a variety of ways and for a variety of reasons, most commonly to increase or provide an alternate (and sometimes more convenient) means of communication between students and instructors, and also to post course materials and information. These uses do not fundamentally change what takes place in college courses, but instead replace or augment another way of achieving the same end. Most Web-based course activities reported in the published literature are not at the core of the learning process, and so do not yet fundamentally affect how learning takes place in college classrooms. While a handful of Web sites described do allow students to participate in interactive activities, this use is not currently the norm. Little has been reported to date about the differences in the abilities, preferences, and needs of students using the Web; the adaptability of current systems; or instructors' educational goals in using the Web in their courses. Some instructors do report using the Web to enhance communication or to help students become familiar with technology, as well as to provide individualized experiences for students.

Of course, the information reported in the literature does not necessarily reflect what is happening with the Web in post-secondary settings as a whole. I did review all articles available on the subject at the time of the study. But the academic literature generally underrepresents studies which find no effects of particular programs or interventions: statistically significant findings are both submitted and published at a greater rate than findings which are inconclusive or non-statistically significant (Light, Singer, & Willett, 1990). It may be that instructors who use the Web in class and find themselves ambivalent about the effects on their students, or use the Web and thereby manage to create some disaster in their classes, are less likely to share their experiences with others. The tone of many of the articles in this study was of one instructor talking to others, hoping to convince them to take up the Web in their own classes. Few instructors want to share their failures with the world, and ambivalent users will not evangelize to others, so these experiences may be occurring but may not be represented in the literature.

In addition, not only is the sample of literature from a self-selected group of authors, but although I did not uncover much data about student differences, Web adaptability, or educational purpose one should not infer these were not present in the settings the authors detailed. It could be that the authors simply did not choose to focus on these topics in their writing. I would hypothesize that this lack of attention to differences and flexibility is at least partly due to conventions which cause instructors and researchers to look at the "best" way to do things for a whole class, without attention to individual differences and how to accommodate them in multiple ways. Articles that provide no information in this respect can neither prove nor disprove this hypothesis.

In order to explore whether, in fact, students and professors perceive each other as individuals with different strengths and needs and perceive the Web environments they use for education as adaptable in particular ways, I conducted an interview study.

Interview Study: Method

In an attempt to gather more data on instructors' and students' perceptions of individual differences, adaptability, and the educational purposes of Web instruction, I sought out instructors and students who had recently or were currently using the Web in their courses. I planned to talk to these individuals personally, to supplement the scarcity of information in the published literature on individual differences and flexibility of Web-based course tools. Was a lack of attention to individual differences and adaptability in the literature indicative of instructors' and students' experiences and perspectives in the population generally, or was the exclusion of these data in the published articles simply an oversight?

In order to recruit subjects for the interview study, I contacted educational multimedia directors and disability coordinators at several non-elite colleges and universities in the Northeast (a region rich in post-secondary institutions). I focused on institutions noted for their diversity and larger-than-average enrollment of students with learning or physical disabilities, in order to locate faculty members at those institutions who were using the Web. I planned to recruit instructors, along with students in their classes who had different characteristics (e.g., differences in culture, language proficiency, and special needs). I hoped this would enable me to hear perspectives of learners for whom given representations of material were sure to be problematic or especially helpful. For instance, animations depicting course content were sure to be problematic for students with vision impairments, but especially helpful for students who consider themselves visual learners.

From the list provided me by these directors and coordinators, I contacted faculty by e-mail, describing my study briefly, and asking them to participate in a one-hour interview in their offices at their institutions. I also indicated that I would like an e-mail list of their students so that I might contact them in the same way and solicit participation. While, in these lists of faculty members and instructors, the hard sciences and engineering were well-represented, there were also faculty members in a number of other disciplines, including psychology, nursing, and sports education. Of the 24 instructors I attempted to contact, some declined to participate; some did not respond; some responded initially, but not to follow up contacts I made attempting to set up an appointment with them; and some agreed to participate. Ultimately, I interviewed four instructors in person, as well as students of three of those professors.

In each case, once the person had expressed interest in the study, I made arrangements over e-mail or the phone to meet with the professor or the student. From the student, I solicited information on her cultural background, English proficiency, and special needs status, assuring the student that this information would be kept confidential. I met with each subject in person, on his campus, either in his office, lab, or at one of the libraries or student centers on campus. At our meeting, each interviewee signed a consent form, agreeing to participate in the study. I recorded the interview on audio tape so that I could make accurate notes later. We spoke without looking at the technology first, and then looked together at the Web site each was using for his course during the second half of the interview. I spent between an hour and two hours with each

person. Students were each paid $10 for their participation; instructors were promised a copy of the final study report as thanks for participation. The interview protocols I used (which focus on the same eight areas of interest as my literature review) are contained in Appendix C.

I planned to speak with students who had a variety of characteristics and so might face barriers of cultural knowledge, language comprehension, physical access to materials, and cognitive access to materials, as well as students who did not face these special challenges. Toward this end, I attempted to locate both male and female students in the following five categories: (1) international students fluent in English; (2) students with limited English proficiency; (3) students having a learning disability; (4) students having a vision, hearing, or motor-related disability; and (5) students without these characteristics.

I contacted 154 students. Of these students, some declined to participate; some did not respond; some responded initially, but not to follow up contacts I made attempting to set up an appointment with them; some committed to a particular date, time and location for the interview but did not appear; and some participated in an interview. I interviewed all the students who consented to participate and who appeared at either our first or second scheduled interview (I attempted to re-schedule all students who scheduled but missed a first appointment with me). While faculty members who expressed interest generally followed up with me, getting busy students to commit to a time, appear, and complete the interview was much more difficult that I had anticipated.

I interviewed 16 students in all, in three classes at the two institutions. I spoke with "traditional" undergraduates, older undergraduates returning to school for a first bachelor's or to prepare for a career in a field different from that in which they had originally trained, graduate students, and students not enrolled in degree programs. All told, I spoke with five international students, two of whom I identified as having limited English proficiency; one student with a learning disability; no students with sight, hearing, or motor-related disabilities; and ten students without identified special needs. In Table 2, I document the categories of students I attempted to locate and interview and those I actually spoke with.

Table 2: Comparison of characteristics of students I contacted, attempted to locate, and actually interviewed.

Students contacted	**154 students**				
Sample sought	**5** International students	**5** Students with limited English proficiency	**5** Students with a learning disability	**5** Students with a vision, hearing, or motor disability	**5** Students with none of these special needs
Students located & interviewed	**5** International students	**2** Students with limited English proficiency	**1** Student with a learning disability	**0** Students with a vision, hearing, or motor disability	**10** Students with none of these special needs

While I spoke with a group of students who were diverse in many ways, I was unable to locate -- let alone recruit -- students in several of the categories I had originally specified. This may be, in part, because the students were not there to be found. Several of the professors I spoke with indicated that they taught a student with a learning or physical disability on average perhaps once a year, despite the fact that I had selected their institutions partly because they reportedly had a greater than average number of students with learning or physical disabilities. The reason for this may be that the students I was looking for are not spread equally across the disciplines. As one professor stated:

> I'm surprised at how many disabled students I see on this campus. I mean, there's a lot of students in wheelchairs and walking with braces and the like...I taught [at another institution] for seven years and I never saw one...This place is much more accessible and accepting of people with disabilities...They're just not in the sciences.

Yet, as in the published literature, the professors who responded to my requests for interviews about their use of the Web were primarily in the sciences or technical fields. I had selected professors who taught large courses, and then attempted to recruit a diverse array of students in those particular classes. In hindsight, it might have been a more effective strategy to attempt to recruit students with particular characteristics first, and work backwards to find a match between them and their professors and students without special needs in the same courses.

I should also note that each institution where I interviewed was diverse in some ways but not others. The urban school tends to enroll students who are diverse in terms of country of origin, race, and culture, but who are relatively homogeneous in age. The suburban institution I selected is primarily composed of white Americans of European heritage -- "I have my first black student in eleven years this year," noted one professor -- who vary greatly in age, school experience, and outside responsibilities.

Interview Study: Findings

A summary of the information I gained through my interviews is contained in Table 3, below. Specific commentary follows.

Table 3: Summary of information from interviews with instructors and students about Web use in post-secondary settings in the northeastern United States. (n = 20)

	Yes, information reported	No information reported	Examples
(1) Student profiles	20 people	0 people	Undergraduates; undergraduates and graduate students; older undergraduates.
Differentiation?	15 people	5 people	Level of knowledge about subject matter and/or technology; gender; major; facility with English; outside responsibilities; age; education.
(2) Class topic	20 people	0 people	Athletic Training Mathematics Molecular Biology Organic Chemistry
(3) Network tool	20 people	0 people	Instructor-designed Web site; designed Web-based system (Web Course in a Box); Web discussion program
(4) Pedagogical use	20 people	0 people	Course notes on-line; announcements; course information (e.g., syllabus); links to resources; practice exercises; old exams; homework, quizzes, exams; demonstrations.
(5) Context (location and timing)	20 people	0 people	Anywhere, anytime as desired; anywhere, anytime, but responsible for material posted on Web and nowhere else.
(6) Adaptable system components	20 people	0 people	Students can set own pace; users can enlarge/manipulate models on-screen; students can choose whether and what to explore; students may participate in on-line discussion or not.
(7) Educational purpose	20 people	0 people	Learn about useful computer resources in the content area (e.g., journals, tools); acquaint students with technology; enable quick feedback; provide extra resources for interested students; provide multiple perspectives and routes into the content material; provide information ahead of time so lecture can be used more effectively.
(8) Evaluation	19 people	1 person	
Experimental Performance	0 people	20 people	
Experimental Affect	0 people	20 people	
Anecdotal Performance	5 people	15 people	Professor believes students using Web do not perform better on exams. Several students claim access to Web improved grade.
Anecdotal Affect	19 people	1 person	All students interviewed claimed they liked using the Web for class, though several mentioned that they could understand how someone not familiar with computers would not. Professors indicated some students like, some don't like, using computers for class.

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The results of the interview study were generally in keeping with the findings from the literature review.

(1) Student profiles. When queried, both professors and students acknowledged that the students in their classes were diverse, though not across the five categories I had originally specified. As one professor stated, "Different people come from different backgrounds, and I have to be aware of that." Some classes had students from a number of different countries of origin, while one had students who were primarily white Americans of European descent. But within each course, students differed greatly in their ages, majors, outside responsibilities, experience with the subject matter, and, notably, comfort with computers. While some students had jobs working with computers and indicated they felt very comfortable with technology, several students described themselves using terms like "computer stupid" and "backward technologically."

It seems likely that these findings from the interview study represent the reality beneath the published reports in the literature review. Though many of the research articles did not report on the diversity of the student populations in the courses described, there is probably diversity along some continuum -- race, age, subject matter experience -- in all classes.

(2) In the case of the interview study, like the literature review, all Class topics were from the sciences as opposed to the humanities (athletic training is a rigorous course which covers a great deal of physiology).

(3) The Network tool used in the courses was the Web: three professors developed their own Web sites, while one built his Web site using Web Course in a Box. Some professors used a canned threaded discussion program as part of the course, while others supported only private e-mail communication with and between students. This mirrors the descriptions in the literature review.

(4) Pedagogical use. All four professors posted course information (e.g., syllabi) on their Web sites, as well as links to resources like on-line journals and Web tools. Some professors included course lecture notes, which were well-received by students, and some included old exams for student practice. Some professors also posted homework assignments, quizzes, and demonstrations or simulations. One professor actually conducted "take home" course exams over his Web site. Some, but not all, professors included on-line discussion forums as part of the course, with varying levels of success, and some instructors also had students post information to share on personal Web pages.

Like the findings reported from the literature review, the uses of the Web reported in the interviews primarily replace or augment previous course practices, without fundamentally altering what happens in the classroom. For instance, the professors who included exams on their Web sites -- including those who used exams which counted toward the student's grade -- invariably suggested to students that they print out the exam and work on a hard copy. Students would therefore go to the Web site, print out a practice or take-home exam, work on the paper copy and record their answers there, and then return to the Web site to key-in their answers. While the method of access may be more convenient, this is really another method for distributing a paper take-home exam. Certainly students with particular needs or preferences

would be able to alter the font size of the text before printing the materials if they knew where to make these changes in their Web browser. And while instructors could draw on models or simulations in the questions that would only be visible on a Web site, to my knowledge, none of the instructors in my sample did.

(5) Context. Unlike the requirements for some courses in the literature review, no students in the interview sample were required to log on to course Web sites at particular times. Students were often held responsible, though, for material on a course Web site that was posted there and nowhere else. The students who took their exams on line had a two-day period in which to take and submit the exam, and students with on-line assignments were required to submit their answers by a certain date.

(6) Despite the many ways in which Web-based course components could be made adaptable (as described in the summary of the literature review, page 5), my question about Adaptable system components seemed to stymie many interviewees. Respondents often had a difficult time thinking of any ways in which the course Web sites were adaptable to different people's preferences and needs. Some on-line demos and illustrations could be manipulated (that is, enlarged and rotated). And students did frequently cite the choice they had as to whether or what they wanted to explore, and whether or not they chose to participate in on-line discussions. While students often saw many routes into the material, they stated that all routes were essentially mandatory to get a good grade in the course and understand the course content. While professors acknowledged that their students were different, they struggled with how to accommodate diverse students within the limited time available:

> It's so painful for me to put information out there, it's so slow getting assignments out there, that I rarely have a case where people can choose from one assignment to the other...I wish I had a way of more quickly generating [exercises for the students], but it's work.

According to another professor, making multiple versions of the work "is not trivial. It's a little time consuming."

But, as one professor pointed out, putting the material on the Web does give students a different way into the material than just lecture, which he admitted can be boring:

> I can get more information out to them in a different way. Or the same information in a different way. So if I'm not getting them there [in class], I'm trying to get them some other way too.

Once again, this is a case of augmenting currently available class practices, rather than providing a truly new experience. Still, at least some students appreciate this type of flexibility:

> [The professor]...had a...system...[that] wasn't regimented in the sense that we were confined to study from one type of textbook or from one type of material or resource...all textbooks that are in existence...one might be good for one type of person and another might be good for another type of person.

Overall, students seemed unable to think of ways in which their courses were adaptable or ways in which they could be. The students I spoke with simply do not expect their course environments to be adaptable to individual students' particular preferences, strengths, and needs. It seems the literature may not have focused on this topic because, for most students and instructors currently using the Web, the level of adaptability of course materials and activities is not currently considered an important pedagogical issue.

(7) Professors in this study had many of the same Educational goals for the use of the Web as were reported in the literature review. While each professor's stated goals were different, these goals included helping students learn to use resources relevant to a particular field on the Web, helping students become familiar with technology as an end in itself, providing extra resources for interested students, providing multiple perspectives on course material, providing lecture material ahead of time so lecture could be spent on more than the transfer of information, and allowing students quick feedback on tests, homework, and exams while saving the instructor the trouble of grading. Notably, some students (and one professor) believed that their reasons for using the Web were less about education and more about convenience:

> He probably did more through the Web than he would have done if he had to make the copies himself and pass them out and go over everything...it was easy for him to just put it out there...it took a lot less work.
>
> I think it's just a convenience thing.

Student perceptions aside, all professors stated that it took them longer to get their Web pages together than it would have to prepare class without the Web. Some did admit that they hoped to be able to build on the site year after year (so the initial workload would result in less of a workload in future).

(8) Evaluation. Not surprisingly, none of the professors I spoke with had conducted controlled studies of their classes to determine whether the Web was helping students learn or find more satisfaction in their courses. Some professors indicated it was too soon to estimate whether students were doing better in the courses or not. One professor stated definitively that his students' grades had not improved, on average, since he installed a Web site as part of his course.

Although some students indicated that they were not initially comfortable with computers, or particularly interested in using a Web site for class, by the time I spoke with them, all were fairly positive about the use of the Web in the particular course:

> I must say, it was kind of fun.
>
> I was really impressed with it; I thought it was a really good idea.
>
> I loved it. I was amazed. I really loved it.
>
> The Web site itself, with the exams and everything, I loved it.

> That's why I liked this class. Because I think the professor is right [to use the Web].
>
> My class that I'm taking right now [in the same subject area], I wish she had a Web page so I could go back [and double check particular concepts or definitions].
>
> I think it would help in all classes, really, to have something on-line to make people get into it.

A few students even indicated that they believed they performed better as a result of using the Web:

> It helped my grade to be able to go and check those different things out...and get...a different perspective on things than just...one professor or one book or one author.

Yet some students also mentioned limitations in the way a course Web site was implemented. For instance, in the case of homework questions being asked right on the screen, in the context of the lecture information about the subject:

> I just find that I don't remember it as much if it's right there in front of me in the on-line...Even though you do it right there, you may not really understand it.
>
> It would be a lot easier to just get the test and look...stuff up in the book, and not actually retain it...I think the Web based class makes it easier not to learn.

Students felt that their successful completion of one professor's self-check exercises embedded in his on-line lecture notes gave them a false sense of security. While students could do the simple exercises on the lecture pages, the course exams proved much more difficult.

Interview Study: Interpretation

While professors recognize differences in their students, they are currently unsure of how to accommodate those differences. The students in my sample do not seem to have the expectation that their course materials or experience should be adaptable to their own preferences, strengths, and needs, nor do they think of ways in which this could be accomplished. Because I was unable to recruit students with learning or physical disabilities for the interview study, it's unclear from my data whether particular students in these categories share this perception.

Given that most professors and students seem to approach course learning with the Web in terms that do not make adjustments for individual differences, what are the current best and worst practices, as described by my sample? In speaking with students about their use of the Web in their courses, I encountered many opinions about what worked and what didn't. These findings are summarized below. Even in my limited sample, not all best practices were preferred by all students. By providing these elements as <u>options</u>, instructors will come closer to creating Web-based environments that are responsive to more individual's preferences, abilities, and needs.

In addition, because I was unable to recruit any students with vision, hearing, and motor related disabilities, I include information from a project conducted at CAST (the Center for Applied Special Technology) last year involving individuals with low incidence disabilities.

Best Practices

1. Putting resources on the Web that show a dynamic process or which allow the student to see something in a new way. For example, with on-line 3-D modeling or a simulation:

> It's really cool 'cause then you can twist it and turn it. And it shows the concepts of when a nucleophile attacks another substrate you can actually see why it won't react or why it will react...If you're not...a person that can look at a piece of paper and visualize the electron cloud around an atom it makes it so much easier.
>
> I think it's [on-line animations] really helpful...it helps a lot to be able to turn it...and actually see how the size of the atoms and stuff affects how the molecule's shaped.
>
> Instead of just describing it, it actually showed the physical steps of what happens.

In terms of my research questions, this practice was present in some classes in the sample, but to a fairly limited extent. On-line simulations can be made adaptable by allowing the student to build, configure, manipulate, and control the display (color, size, contrast) of the model. Care should be taken to provide equivalent text or audio representations of any visual models to provide access to students with vision related disabilities.

2. Providing outlines of class notes as far in advance of the class as possible. This practice benefits many types of students. One professor mentioned that he had formerly made his printed class notes available only to a student with a hearing impairment so she could watch an interpreter during class without having to worry about taking notes at the same time:

> Now all the notes go on the Web page...the idea is...[all the students] can review it before they come in and...we can have more discussion...If I say here's a particular injury, this is how it happens, this is the population it happens to, here's the mechanism, that's all me telling them that. If they read it first, then we could say...let's think about it -- where else do you think this might happen? So it makes it a little bit more problem solving, critical thinking.

According to students, this seems to work:

> It's a hell of a lot easier to highlight the stuff than it is to write notes. So, I mean, it makes lecture a lot less writing intensive where you can actually listen to him and try and grab the concepts he's trying to present...so that's what I see as a heck of an advantage for it.
>
> It's been really interesting and really helpful for me...I find I don't write as fast or type as fast as I read, so a lot of times it's harder for me to take notes than it is to read something and just jot down little reminders of things in the margins.

> He put it there, so I know that's his information for the quiz instead of my perception of the notes.
>
> I personally really enjoy it...you can always go back, and, most times when a professor lectures to you you're writing down your interpretation for what he or she has said. Whereas with this, you can go back to the lecture material and it's all right in front of you and it's exactly how he said it and exactly how he wants you to learn it.

Making lecture notes available also helps other students with special circumstances: students who have difficulties understanding another's spoken English can look on the class notes to be sure they have the correct terms, a strategy several students (both those having difficulty understanding American English and those having difficulty understanding the English of a student not from the United States) mentioned using:

> I don't want to embarrass [the] person...I would remember what he said or she and go back to [the] book...and find out for myself.

Several professors in the interview sample provided at least some class notes, and all students who mentioned having access to them were enthusiastic about the possibilities they afforded. In terms of individual differences and adaptability, notes on-line in a digital format allow students to view the notes in a type size and contrast that suits them, rearrange the content in word processing programs (to make flash cards or study outlines), and print them and bring them to lecture, section, or study group. Students can read the notes ahead of time or after lecture, and can preview the notes at the beginning of the course or review them at the end. Students can also take their own notes and compare these to the instructor's. The notes provide an alternate route into the course material, in addition to any text, labs, lectures, or discussions which house course content. In this way, students are able to use the notes to obtain many different entrees into the course material.

3. Providing an on-line discussion forum. In this way, students can stay tuned into class even when they are away, post questions later if they need more time to think or weren't at their best during class time, and discuss course concepts with other students:

> It was definitely helpful to see what other people had questions on...I could be like oh yeah I know that and maybe answer their question or...realize that maybe I was confused about that too so I would go back and re-go over the material.
>
> You could actually study at home and then if you're not sure about [an] answer you go to Web site and check what other people think about that question...I think that was...very nice...it was very...interactive.
>
> I probably spoke up more on the Web than I would have in class.
>
> On the Internet even though there is your name, it's much easier to ask there because people can't see you.

> I feel like you might miss something [asking questions in] the e-mail [as opposed to an open threaded discussion]...you don't see the individual e-mails come through...we don't hear the questions...and it may be another way of looking at it.

The most successful Web discussions (1) had a particular topic of discussion specified, (2) were moderated by the professor, and (3) were run by professors who left plenty of time for students to wrestle with and answer questions before they posted their own response.

This option was one of the more common aspects of Web-based courses in the literature and the interview study. Discussions can be made adaptable by allowing students to specify certain parameters of the discussion. (Options include discussions which center on particular topics suggested by the professor or by students; discussion formats which allow for selections of font size and color and inclusion of still and dynamic graphics and sound; discussions which allow students to post queries openly or anonymously, to individuals, small groups, the whole discussion list, or just the instructor; and discussion formats which allow for sorting of postings by date, subject, author, and so on.)

4. Providing students the chance to be active in their own learning, including practicing course material in the form the final assessment will take:

> There were some special things about this class. The professor...wanted to give us freedom to do some research by our own minds, not just give us...materials from [the] textbook. You know, some professors like to do a lot of stuff on [the] blackboard and the students just take notes. That's not a good way to learn something.

> I definitely think the one thing I took from that class was...an understanding of how I could use what he taught me and bring it into a problem and use it to solve that problem without actually being taught how to solve that problem.

Most instructors in this study required that students interact in some way with the course material on the Web site, but much of this access was purely for posting and retrieval of information. Adaptability would imply students would not only take responsibility for learning the material, but that they would have a chance to select how they learned the material, and perhaps even what topics they would focus on.

5. Providing a Web site in conjunction with (not in place of) face to face interaction with the professor and other students.

> I'm realizing that I understand [the material] better when I talk it over with other people.

> I think [the Web] is a great tool...but I also...like to talk with a teacher and the guy be right in front of me...so I can ask the question.

While all the individuals I spoke with currently use the Web as a component of a face-to-face course, some instructors and students spoke as if the course would inevitably turn into a distance-education course without any in-person contact. Adaptability concerns would suggest

that students should be given different options for interacting during the course, from speaking up in person in a large lecture hall to sending a private e-mail to someone in the class. By providing two different ways to communicate (face-to-face and on-line), in both large (public) and small (private) groups, the instructor provides multiple options for students to engage with and explore the course material in the context of other people.

Less Effective Practices

Students were less pleased with certain aspects of their course Web experience. They did not enjoy waiting while the professor spent class time trouble-shooting or setting up the computer system. They were frustrated when professors made changes to their Web sites but made no indication there had been a change (so the student was left not knowing if she had the most up-to-date version of a page or not). Students also had trouble sorting through a large threaded discussion that was organized only by reverse date order. Finally, several students were frustrated by the fact that they were not awarded partial credit on computer-graded multiple choice exams (which are the easiest type of exams to host on-line):

> If you make a dumb mistake or you make a mistake 'cause of the way the question is written, and you mark the wrong answer, it's wrong. Whereas you might have gotten partial credit or showed you at least knew what he was talking about.

Despite these complaints, the response to the use of the Web by the students I interviewed was overwhelmingly positive. Once again, I cannot judge what the response of students with particular disabilities would be, as these students were not represented in my sample. We do know from the CAST study of students with vision, hearing, and motor-related disabilities (Follansbee, 1999) that both visually and physically impaired students appreciate having core course materials in digital formats. With digital materials, students with severe visual impairments can access the materials with assistive technologies (e.g., screen readers), and students with physical disabilities can copy and paste digital materials into their preferred software, through which they can access, navigate, and create materials without relying on others to translate materials and take notes for them. While students with hearing impairments do not require digital versions of text-based materials, these students do require text support for multimedia materials (e.g., captions for or transcripts of audio tracks used in sound recordings or videos). These students also appreciate language support, such as spell checking, grammar checking, and pronunciation guides. As mentioned earlier, students who are deaf or have severe hearing impairments also benefit from on-line lecture notes, so they can concentrate on watching an interpreter -- not taking notes -- in class.

Interview Study: Discussion

In the United States, the "traditional" model of college teaching is gradually shifting to a more constructivist model. A pedagogical model with the professor as primary expert and source of knowledge, passing on information to students in a full-frontal lecture, with students assessed via one-size-fits-all exams is fading. In its place, models of teaching are emerging in which there are multiple perspectives on a subject, and students are encouraged to learn in hands-on ways, sometimes in groups, often from each other. Those professors I spoke with who are using the Web seem to be feeling this influence in their own teaching, and what they are doing is being influenced by what the Web makes it easy to do.

As indicated by many of the comments recorded in this study, the Web makes many perspectives available to students. Digital storage makes it easy to present and draw on information from multiple sources, including multiple textbooks, from all around the world. Students can log in and check their work at any time, from anywhere, and can leave messages for each other and for instructors via e-mail or threaded discussion forums, staying in touch with the class outside the specified lecture time. Because lecture no longer needs to be used for the transfer of information (lecture notes can be posted directly on a Web site), it is increasingly being used for something more interesting to students (analysis, synthesis, discussion). When exams and quizzes are on-line and students can take them anywhere and anytime, professors cannot ensure that students do not use their books. Thus the questions asked cannot be simple memorization questions that the students could easily look up in print references or on-line. More and more, Web-based assessments may require some kind of synthesis or analysis of the material, forcing students to learn to solve problems, rather than memorize information.

We are currently in a stage where much of what is happening still occurs within non-digital models. Like the students who print their exams and work from paper copies, we have not yet made the change to using Web-based materials in a truly new way. While current practices do more to augment and replace traditional classroom practices than to transform them, the spread of the use of the Web in post-secondary settings continues to be swift. I would expect rapid change not just in who uses Web-based tools, but in how they are used. The same professors I interviewed for this study may have radically different pedagogical practices in a year's time. This highlights another important point: while I did not find large samples of students with special needs in the Web-using populations I surveyed, I would expect the rapid spread of Web-based curricula to non-technical courses with more students who have special characteristics and needs. These students will most likely require (and the law mandates that they have) learning environments which are adaptable to their needs. For this reason, now, more than ever, we need to devote energies to determining what makes a successful Web-based environment for all learners, so that no one is left out as course-based Web use spreads.

Interview Study: Conclusions and Caveats

While the findings from the interview study were generally in keeping with those from the literature review, the interview study also provided powerful evidence not present in the literature. The literature review provided no data in response to my second research question. From the literature, I could not say whether professors and students perceived their learning environments as diverse, nor whether they noted or required flexibility in their course materials, as these subjects simply were not mentioned in the articles I reviewed. Based on data from the interview study, I can now say definitively that in my sample, students and professors do indeed perceive their classes as diverse, but that they invest little energy thinking about the potential flexibility of course materials.

Still, in the interview study, I did not escape the problem of self-selection of the sample. Those professors who volunteered to participate in the study were interested in the Web (three were or had been the developer of their department's Web site, and the fourth professor claimed he currently spends 10-14 hours a day working on his Web site). In addition, while some students and most of the professors I spoke with indicated that some students like the Web and some don't, all the students interviewed for this study said they enjoyed using the Web in class. This

obviously does not fully represent the range of opinions about the Web in post-secondary environments generally. In order to get a fuller perception of Web use, it would be necessary to talk to all members of a given course, especially students with various kinds of disabilities.

The Studies: Conclusions

I now revisit my original research questions.

- What are the prevalent ways in which particular network technologies are currently used in higher education settings?
- How adaptable are the components of the network tools, embedded in particular teaching and learning environments, for students with different preference, strengths, and needs?

While I explored these questions in previous sections, the following two tables succinctly summarize the aspects of the literature review and interview study which address these questions explicitly. Table 4 looks at the ways Web-based network technologies are currently used in higher education settings, while Table 5 reviews the level of adaptability currently noted in those settings.

Table 4: Prevalent ways in which Web-based technologies are used in higher education settings as realized in the literature review and interview study.

	Literature Review	Interview Study
Presentation Augment & replace current practices	• Post access course materials (syllabus, calendar, lecture notes, grades) • Present access static examples (e.g., textual information) • Archive materials • Explore links to other Web sites	• Post access course materials (syllabus, calendar, lecture notes, grades) • Present access static examples (e.g., old exams) • Archive materials, course knowledge • Explore links to other Web sites
New practices	• Present access interactive/dynamic examples (e.g., simulations) • Create links to other Web sites	• Present access interactive/dynamic examples (e.g., demonstrations) • Create links to other Web sites
Communication Augment & replace current practices	• Share course info with peers (post own projects) • Interact textually with "guest speakers" • Give feedback about site • Submit assignments	• Post access course announcements • Share course info with peers (post own projects) • Submit assignments
New practices	None	None
Collaboration Augment & replace current practices	None	None
New practices	None	None
Discussion Augment & replace current practices	• Asynchronous (e-mail) and synchronous (chat) discussion of grades, course content between students & students & instructors	• Asynchronous (e-mail, threaded discussion) discussion of content, questions, study problems between students & students & instructors
New practices	None	None
Research Augment & replace current practices	None	• Post/explore links to relevant journals, databases
New practices	None	• Post/explore links to relevant on-line tools
Assessment Augment & replace current practices	• Complete ungraded static exercises, tutorials • Take graded multiple choice quizzes • Publish course essays	• Complete ungraded static practice exercises • Complete work on-line • Take graded multiple choice quizzes, exams • Publish course essays
New practices	• Complete ungraded interactive exercises, tutorials, virtual labs	None

Table 5: Level of adaptability noted in Web-based environments in post-secondary settings according to conjecture, literature review, and interview study.

	Possible examples	Literature review	Interview study
Means of physical access/ configuration	• Alter size, color of text, background, other on-screen elements • Hear on-line text spoken	• Change on-screen colors	• Enlarge/ manipulate on-screen models
Means of exploration/ practice	• Select method of navigation (menus, buttons, map, control panel, hot keys, single switch) • Choose own activities or allow system to present activities • Enter an activity through multiple content routes (example, question, problem, fully worked solution, partially worked solution, scenario)	• Select method of navigation (linear, hierarchical, via spaces, map, menus, control panels, hot keys)	• Set own pace
Means of communication/ discussion	• Communicate via text, recorded speech, video	• Appear publicly or privately; or anonymously	None
Means of expression/ presentation	• Use text, recorded speech, static or dynamic visual imagery, music, sound to express ideas, course concepts, demonstrate understandings	None	None
Means of assessment	• Choose own topic(s) • Timed or untimed • Competition with class members or criterion referenced • Choose format (multiple choice, fill in blank, essay) • Choose modality (audio, visual, text) • Short (hours) or long (days) format to complete work • Build from nothing or work backwards from a completed example	None	None

In summary, according to current reports of Web use at the post-secondary level as presented in the literature and in an interview study, students are encountering Web-based learning at all levels (undergraduate, graduate, professional school), and in many different types of institutions (elite, second-tier, community college). The majority of courses which use the Web are still concentrated in scientific and technical subject matters, such as computer science, engineering, biology, and chemistry, which do not include many students with identified special needs. Instructors are using the Web in a variety of ways and for a variety of reasons, most commonly to increase or provide an alternate (and sometimes more convenient) means of communication between students and instructors; to provide links to outside resources; and to post course materials and information, including old or practice (ungraded) tests and exams, which students generally print out. A handful of Web sites allow for students to participate in interactive activities, but this use was not widespread at the time of the study.

While many instructors (and all of those I spoke with personally) acknowledge that they teach diverse populations of students, they struggle with how to meet the students' differing needs when time is short and the development and maintenance of Web-based course sites is so time consuming. As is apparent from Table 5, most Web sites do not have multiple ways for students to engage with course materials based on their individual preferences, strengths, and needs. Nor is this expected by students in the populations I surveyed.

My findings seem to point to the fact that not much is being done to accommodate diverse users in university settings; the results from this study seem, perhaps, unexciting when compared to the hype about the Web's potential. Adaptability of course materials was not possible until digital technology became widely available, a development which took place within the last couple of years. Now adaptability is theoretically possible, but so few models of adaptive practices exist, people do not know how to demand it. The students I spoke with could not think of examples of what they would like to have the technology do especially for their own needs. But as McLuhan noted, people did not know they wanted motorcars until there were motorcars (McLuhan, 1994). Had I asked the students in my study if they would like to be able to pick their own assignments, configure the presentation of course materials, or choose their own forms of assessment, the responses may have been quite different. I note that students in this study frequently mentioned practices they encountered in other courses and liked.

In addition, the instructors I have worked with -- in this study and in others -- are often motivated by the chance to provide an engaging and rewarding learning experience for students. While effective teaching never has been the primary criterion for tenure, many professors continue to care deeply about their teaching. And adaptable environments, when constructed well, provide better learning environments for all students, not just those with disabilities.

As the use of Web-based materials to support learning continues to spread, and as the number of "non-traditional" learners in post-secondary institutions increases, it is critical that we better understand the needs of diverse learners, and try to put our knowledge into practice. Formerly, these learners were ignored and left out of learning contexts. Today, digital formats enable us to allow these learners to share in learning experiences with other students. While the findings from my two related studies have made the terrain a bit clearer, they have not gone far enough in helping us understand diverse students' needs from a research perspective. By the same token,

instructors, while they dabble with the Web, have not paid enough attention to accommodating different kinds of students actively in their courses. The responsibility rests on both sides. Researchers need to focus more on understanding how diverse learners benefit from particular practices and share that information more effectively with practitioners. Practitioners, in turn, need to work harder to accommodate different kinds of students in their courses. Both of these approaches are essential if we are to develop strategies to accommodate all students in a medium that can -- but currently does not -- support multiple ways of learning and knowing.

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Appendices

Appendix A
Literature on Network Learning in Higher Education Examined

Appendix B
Questions Applied to the Literature on Network Learning

Appendix C1
Interview Protocol for Faculty Members Engaged with Network Learning
Appendix C2
Interview Protocol for Students Engaged with Network Learning

Appendix A: Literature on Network Learning in Higher Education Examined

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Appendix B: Questions Applied to the Literature on Network Learning

Student profiles (1)

- Are the profiles of the students (e.g., first-semester public college students whose native language is not English) using the technology reported in the article? If so, what are they?
- Does the article's author differentiate between students, or does the author consider the students as a homogenous group?

Class topic (2)

- Is the class topic or course title (e.g., Introduction to Composition) identified in the article? If so, what is it?

Network tool (3)

- Is the kind of network tool (e.g., text-based asynchronous threaded discussion) being used identified by the author of the article? If so, what is it?

Pedagogical use (4)

- Is the kind of pedagogical use (e.g., presentation, communication, collaboration, discussion, research, assessment) associated with the tool identified by the author of the article? If so, what is it?

Context (location and timing) (5)

- Is the context (the location and timing) of the instruction (e.g., a 16-person on-campus computer lab during class time) identified in the article? If so, what is it?

Adaptable system components (6)

- Does the author mention any way in which the system is adaptable (e.g., option for text-to-speech and choice of size of display font) to the particular user? If so, in which ways?

Educational purpose (7)

- Is the educational purpose or goal of the network-based instruction (e.g., to overcome students' fear of writing by seeing others' writing in progress) identified in the article? If so, what is it?

Evaluation (8)

- Is the data reported empirical or anecdotal?
- If they are empirical, what type of data (e.g., student responses on a post-class questionnaire) does the author report?
- Are there measures of students' performance (e.g., test scores)? If so, which?
- Are there measures of students' affective experience (e.g., survey responses in which the student indicated whether she enjoyed using the tool)? If so, which?
- What were the outcomes on these measures?

Appendix C1: Interview Protocol for Faculty Members Engaged with Network Learning

Student profiles (1)

(1) What school and program do you teach in, and how long have you been there? What year are your students?

2. What is the range of cultures or nationalities of the students? Do many speak more than one language? If so, which? Do you have any students who have difficulty with English?
3. Do you have any students with identified disabilities (physical, learning) that you know about?
4. How would you rate the skill level of your students with the material you teach? Have most had experience with it before?
5. Do you feel comfortable with technology? Have you used technology before in a class? Do your students feel comfortable with technology?
6. Do you think your students are fairly homogeneous or heterogeneous? In what ways? Is there anything you try to do to compensate for differences you see?
7. Is there anything else about your students you'd like to share?

Class topic (2)

(1) What's the title and topic of the course that you teach? What do you like, dislike, wish you could change about the course?

Network tool (3)

1. What kind of network tool(s) do you use in or for class? (Prompt with examples if necessary.)

Pedagogical use (4)

1. What do you use the tool for (presentation, communication, collaboration, discussion, research, assessment)? Is this helpful for you? For the students?
2. What do the students use the tool for? Is this helpful for the students? For you? What do you wish the students would do with it, if anything?
3. How does the tool fit in with the rest of the work in the class? Is it used a lot or a little? What typically happens in class when you're not using the tool (lecture, discussion, group work, Socratic method)?

Context (location and timing) (5)

1. Where and when do your students use the network tools (at school, at home, during class, on their own time)?
2. Where and when do you use the network tools (at school, at home, in your office, during class, on your own time)?

Adaptable system components (6)

1. Can you think of any ways in which the system is adaptable to your preferences? If so, in which ways? Can you show me?
2. Can you think of any ways in which the system is adaptable to your students' preferences? If so, in which ways? Can you show me?
3. How adaptable are the other parts of the course (readings, lecture, discussion, group work)? Which parts, in which ways?

Educational purpose (7)

1. What's the educational purpose or goal of this network-based instruction? Does it achieve that goal?
2. What's the goal of the class? Is it achieved with your students?

Evaluation (8)

1. Do you like using the tool? Why or why not?
2. Do you think it helps you do anything more easily or more effectively? If so, in what ways?
3. Do you think it helps the students do anything more easily or learn more effectively? If so, in what ways? For which students?
4. Can you think of any way the tool could be improved?

Appendix C2: Interview Protocol for Students Engaged with Network Learning

Student profiles (1)

1. What school and program are you in, in what year? Do you like the program?
2. What is your country or state of origin? Do you speak more than one language? If so, which? Do you have any difficulty with English?
3. Do you have any disabilities (physical, learning) which you would be willing to share with me?
4. Do you feel comfortable with technology? Have you used technology before in a class?
5. Is there anything else about yourself or your background that you'd like to share?
6. Do you think the other students in the class are like you or unlike you? In what ways?

Class topic (2)

1. What's the course title and topic? How do you like the class? Have you taken a class in this subject matter before?

Network tool (3)

1. What kind of network tool(s) do you use in or for class? (Prompt with examples if necessary.)

Pedagogical use (4)

1. What do you use the tool for (presentation, communication, collaboration, discussion, research, assessment)? Is this helpful? Do you like it? If you had your choice, what would you do with it, if anything?
2. What does the instructor use the tool for? Is this helpful? Do you like it? What do you wish the instructor would do with it, if anything?
3. How does the tool fit in with the rest of the work in the class? Is it used a lot or a little? What typically happens in class when you're not using the tool (lecture, discussion, group work, Socratic method)? What do you wish would happen in class?

Context (location and timing) (5)

1. Where and when do you use the network tools (at school, at home, during class, on your own time)? Could you use the tool at times and places that you don't? If so, what are they, and why don't you use them? If you could use it anywhere and anytime you wanted, where and when would you?

Adaptable system components (6)

1. Can you think of any ways in which the system is adaptable to your preferences? If so, in which ways? Can you show me?
2. How adaptable are the other parts of the course (readings, lecture, discussion, group work)? Which parts, in which ways?

Educational purpose (7)

1. What do you think the educational purpose or goal of this network-based instruction is? Does it achieve that goal for you?
2. What do you think the goal of the class is? Does it achieve that goal for you?

Evaluation (8)

1. Do you like using the tool? Why or why not?
2. Do you think it helps you do anything more easily or learn more effectively? If so, in what ways?
3. Do most students use it in the same way you do? Is there any way you use it differently than most people?
4. Can you think of any way the tool could be improved?